Citation 2

PATENT ABSTRACTS OF JAPAN

(54) EXTRACTOR FOR FEATURE OF SKIN SURFACE SHAPE BASED ON RESTORATION OF THREE-DIMENSIONAL SHAPE FROM IMAGE PERTAINING TO SKIN SURFACE
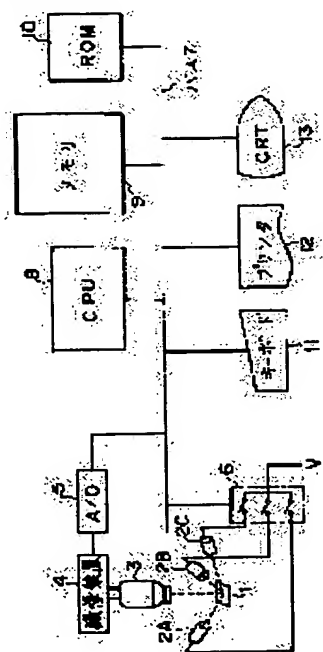
(57)Abstract:

PURPOSE: To enable accurate extraction of features of a skin surface by enabling the restoration of a three-dimensional shape of the skin surface.

CONSTITUTION: A CPU8 controls a switch 6 through a bus 7 and a replica surface is lighted sequentially by a first light source 2A, a second light source 2B and a third light source 2C sequentially to pick up three image data to be obtained from an magnification optical system 3, a camera 4 and an A/D converter 5 into a memory 9 through the bus 7 sequentially corresponding to respective lighting operations. The CPU8 calculates a gradient of the replica surface 1 at the positions of pixels of an image of the replica surface from a lightness value of the pixels of the three image data thereby extracting feature parameters pertaining to a three-dimensional shape of a skin surface based on the gradient.

CLAIMS

[Claim(s)]

[Claim 1] A lighting means to illuminate the shape of skin surface type, and an image pick-up means to output the digital image data which picturize the shape of said skin surface type, and express the lightness value of each pixel location corresponding to each flat-surface location of the shape of this skin surface type, An image data storage

means to memorize said digital image data of two or more sheets obtained from said image pick-up means corresponding to the lighting from [which is depended on said lighting means / two or more] the light source, respectively, An inclination extract means to extract the inclination of the shape of said skin surface type in said each pixel location based on the information on said two or more directions of the light source, and the lightness value acquired from said digital image data of two or more sheets, A description information extract means to extract the description information about the shape of said skin surface type based on the inclination of the shape of said skin surface type in said every pixel location extracted by said inclination extract means, Feature-extraction equipment of the shape of skin surface type based on restoration of the three-dimension configuration from the image about the skin front face characterized by ****(ing).

[Claim 2] A lighting means to illuminate the shape of skin surface type, and an image pick-up means to output the digital image data which picturize the shape of said skin surface type, and express the lightness value of each pixel location corresponding to each flat-surface location of the shape of this skin surface type, An image data storage means to memorize said digital image data of two or more sheets obtained from said image pick-up means corresponding to the lighting from [which is depended on said lighting means / two or more] the light source, respectively, An inclination extract means to extract the inclination of the shape of said skin surface type in said each pixel location based on the information on said two or more directions of the light source, and the lightness value acquired from said digital image data of two or more sheets, The description information about the configuration of the leather slot which is one of the shape of said skin surface type based on the inclination of the shape of said skin surface type in said every pixel location extracted by said inclination extract means, Feature-extraction equipment of the shape of skin surface type based on restoration of the three-dimension configuration from the image about the skin front face characterized by having a description information extract means to extract at least one or more of the description information about the configuration of the intersection field of said leather slot which is one of the shape of said skin surface type.

[Claim 3] A lighting means to illuminate the shape of skin surface type, and an image pick-up means to output the digital image data which picturize the shape of said skin surface type, and express the lightness value of each pixel location corresponding to each flat-surface location of the shape of this skin surface type, An image data storage means to memorize said digital image data of two or more sheets obtained from said image pick-up means corresponding to the lighting from [which is depended on said lighting means / two or more] the light source, respectively, An inclination extract means to extract the inclination of the shape of said skin surface type in said each pixel location based on the information on said two or more directions of the light source, and the lightness value acquired from said digital image data of two or more sheets, The description information about the field of the configuration of the leather slot which is one of the shape of said skin surface type based on the inclination of the shape of said skin surface type in said every pixel location extracted by said inclination extract means, The description information about the area of the configuration of said leather slot, and the description information about the direction of the configuration of said leather slot,

The description information about the depth of the configuration of said leather slot, and the description information about the width of face of the configuration of said leather slot, The description information about the die length of the configuration of said leather slot, and the description information about the number of the configurations of said leather slot, The description information about the field of the configuration of the intersection field of said leather slot which is one of the shape of said skin surface type, The description information about the rate that the pore in the configuration of the intersection field of said leather slot exists, The description information about the depth of the pore in the configuration of the intersection field of said leather slot, Feature-extraction equipment of the shape of skin surface type based on restoration of the three-dimension configuration from the image about the skin front face characterized by having a description information extract means to extract at least one or more of the description information about the magnitude of the pore in the configuration of the intersection field of said leather slot.

[Claim 4] The inclination of the shape of said skin surface type in said every pixel location from which said description information extract means was extracted by said inclination extract means, Feature-extraction equipment of the shape of skin surface type based on restoration of the three-dimension configuration from the image about a skin front face given in claim 1 characterized by what said description information is extracted for based on at least one or more information on extent of change of the reinforcement of this inclination, the direction of this inclination, or this inclination thru/or any 1 term of 3.

[Claim 5] Said description information extract means calculates the reinforcement of the inclination of the shape of said skin surface type in said every pixel location extracted by said inclination extract means. Feature-extraction equipment of the shape of skin surface type based on restoration of the three-dimension configuration from the image about the skin front face according to claim 3 characterized by what the description information about the area of the configuration of the field of the configuration of said leather slot and said leather slot is extracted for based on the reinforcement of this inclination.

[Claim 6] Said description information extract means is feature-extraction equipment of the shape of skin surface type based on restoration of the three-dimension configuration from the image about the skin front face according to claim 3 characterized by what the direction of the inclination of the shape of said skin surface type in every pixel location of said extracted by said inclination extract means is calculated, and the description information about the direction of the configuration of said leather slot is extracted for based on the direction of this inclination.

[Claim 7] It integrates with said description information extract means in the field of the configuration of said leather slot from which the inclination of the shape of said skin surface type in said every pixel location extracted by said inclination extract means is extracted as said description information. Feature-extraction equipment of the shape of skin surface type based on restoration of the three-dimension configuration from the image about the skin front face according to claim 3 characterized by what the description information about the width of face of the depth of the configuration of said leather slot and the configuration of said leather slot is extracted for based on the result

of this integral.

[Claim 8] It is based on the description information about the field of the configuration of said leather slot, the description information about the direction of the configuration of said leather slot, or the description information about the depth of the configuration of said leather slot. Feature-extraction equipment of the shape of skin surface type based on restoration of the three-dimension configuration from the image about the skin front face according to claim 3 characterized by what the description information about the die length of the configuration of said leather slot and the description information about the number of the configurations of said leather slot are extracted for.

[Claim 9] The shape of said skin surface type which is illuminated by said lighting means and picturized by said image pick-up means is feature-extraction equipment of the shape of skin surface type based on restoration of the three-dimension configuration from the image about a skin front face given in claim 1 characterized by what is been the configuration of the front face of the skin surface replica which carried out templating of the skin front face with the templating ingredient thru/or any 1 term of 8.

[Claim 10] The shape of said skin surface type which is illuminated by said lighting means and picturized by said image pick-up means is feature-extraction equipment of the shape of skin surface type based on restoration of the three-dimension configuration from the image about a skin front face given in claim 1 characterized by what is been a direct configuration on the front face of the skin thru/or any 1 term of 8.

[Claim 11] Said inclination extract means presumes the inclination of the shape of said skin surface type based on the information on said two or more directions of the light source, and two or more lightness values corresponding to said pixel location of the present when it is obtained from said digital image data of two or more sheets for said every pixel location. Then, the conditions that said presumed inclination becomes the smoothest between said adjoining pixel locations, Under the conditions that the error for said every pixel location of two or more lightness values with which it corresponds in said two or more directions of the light source which actually picturize and are acquired, and two or more reflectivity which corresponds in said two or more directions of the light source calculated based on said presumed inclination serves as min, the shape of said skin surface type Feature-extraction equipment of the shape of skin surface type based on restoration of the three-dimension configuration from the image about a skin front face given in claim 1 characterized by what said presumed inclination is corrected for said every pixel location, and said inclination acquired as a result is outputted for thru/or any 1 term of 10.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Industrial Application] This invention relates to the equipment which extracts a configuration with a detailed skin front face, and extracts the description information used as the index for judging change by the description of the skin, skin quality, and those aging.

[0002]

[Description of the Prior Art] a partition division is carried out by the thin slot of a large number called a leather slot, and the leather slot in a skin front face -- leather -- the colliculus called a hill, the pore which exists in a part for the intersection of a leather slot exist, and they change in response to the physiological effects of the metabolic turnover of the skin etc.

[0003] Therefore, the feature extraction from the shape of skin surface type serves as an index for judging change by the description of the skin, skin quality, and those aging, and the index offers useful information in fields, such as a therapy of the skin, a diagnosis, and cosmetics health.

[0004] As 1st conventional example of a skin surface type-like feature extraction, templating of the skin front face is carried out by silicone rubber etc., a skin surface replica (negative replica) is created, and there is an approach human being observes it with an optical microscope.

[0005] A skin surface replica is scanned by the sensing pin, using a surface roughness meter as 2nd conventional example of a skin surface type-like feature extraction, it asks for the height of the peak of boom hoisting, a number, a peak area, etc. from the boom-hoisting value signal acquired as a result, and there is a method of judging extent of the irregularity of a skin surface replica side.

[0006] There are the following approaches as 3rd conventional example of a skin surface type-like feature extraction. That is, a skin front face or a skin surface replica side is first illuminated from the direction of plurality, for example, three directions. Next, the lightness value for every pixel which constitutes the image about each lighting image is calculated by picturizing a field with a television camera through an optical microscope for every lighting, and changing the image pick-up signal into digital image data. And to the lightness data obtained by making it such, by performing digital image processing, a geometric feature parameter is extracted and let it be the skin surface type-like description information.

[0007]

[Problem(s) to be Solved by the Invention] However, in the 1st conventional example mentioned above, since evaluation of the skin surface type-like description is subjective evaluation by the view of viewing, evaluation lacks in quantum nature and has the trouble that evaluation takes skill.

[0008] Moreover, in the 2nd conventional example mentioned above, it has the trouble that an observable field will not necessarily be enough to incline toward a part and extract the description of the whole field, and a still more nearly special metering device will also be needed.

[0009] Furthermore, although the overall description of a field can be extracted as a quantitive feature parameter in the 3rd conventional example mentioned above, since the

feature parameter is extracted only based on distribution of a lightness value, the information about the hide depth of flute must be indirectly presumed from lightness distribution.

[0010] Therefore, it has the trouble that it is difficult to ask a detail for judgment results — whether the width of face of a leather slot, the relation between directivity and the hide depth of flute, or the intersection of a leather slot supports pore truly — and the skin surface type-like description cannot necessarily be extracted correctly.

[0011] This invention aims at making it possible to restore the configuration of the three dimension on the front face of the skin, and enabling the extract of the description of the shape of more exact skin surface type by it.

[0012]

[Means for Solving the Problem] This invention has first a lighting means to illuminate the shape of skin surface type, such as a skin front face or a skin surface replica.

[0013] Next, the shape of skin surface type, such as a skin front face or a skin surface replica, is picturized, and it has the image pick-up means which consists of expansion optical system which outputs the digital image data showing the lightness value of each pixel location corresponding to each flat-surface location of the shape of the skin surface type, a CCD camera, an A/D converter, etc.

[0014] Next, it has image data storage means, such as RAM which memorizes the digital image data of two or more sheets obtained from an image pick-up means corresponding to the lighting from [which is depended on a lighting means / two or more] the light source, respectively, or disk storage.

[0015] Furthermore, based on the information on two or more directions of the light source, and the lightness value acquired from the digital image data of two or more sheets, it has the inclination extract means which extracts the inclination (gradient) of the shape of skin surface type in each pixel location, for example, consists of microprocessors which operate with a predetermined control program. This inclination extract means presumes skin surface type-like inclination based on the information on two or more directions of the light source, and two or more lightness values corresponding to the present pixel location obtained from the digital image data of two or more sheets for every pixel location. Then, the conditions that the inclination presumed between adjoining pixel locations becomes the smoothest, Under the conditions that the error for every pixel location with two or more reflectivity which corresponds in two or more directions of the light source calculated based on the inclination presumed to be two or more lightness values which correspond in two or more directions of the light source which actually picturize and are acquired serves as min, the shape of skin surface type The inclination presumed for every pixel location is corrected, and the inclination acquired as a result is outputted.

[0016] And based on the inclination of the shape of skin surface type in every pixel location extracted by the inclination extract means, it has the description information extract means which consists of above-mentioned microprocessors which extract the description information about the shape of skin surface type.

[0017] More specifically, the description information extract means extracts at least one or more of the description information about the configuration of the leather slot which is skin surface type-like one, and the description information about the configuration of the

intersection field of the leather slot which is skin surface type-like one based on the inclination of the shape of skin surface type in every pixel location extracted by the inclination extract means.

[0018] The description information about the configuration of a leather slot is the description information about the field of the configuration of a leather slot, the description information about the area of the configuration of a leather slot, the description information about the direction of the configuration of a leather slot, the description information about the depth of the configuration of a leather slot, the description information about the width of face of the configuration of a leather slot, the description information about the die length of the configuration of a leather slot, the description information about the number of the configurations of a leather slot, etc.

[0019] The description information about the configuration of the intersection field of a leather slot is the description information about the field of the configuration of the intersection field of a leather slot, the description information about the rate that the pore in the configuration of the intersection field of a leather slot exists, the description information about the depth of the pore in the configuration of the intersection field of a leather slot, the description information about the magnitude of the pore in the configuration of the intersection field of a leather slot, etc.

[0020] And the description information extract means extracts the description information based on at least one or more information on the inclination of the shape of skin surface type in every pixel location extracted by the inclination extract means, the reinforcement of the inclination, the direction of the inclination, or extent of change of the inclination.

[0021]
[Function] Since a skin surface type-like three-dimension configuration can be extracted through the inclination in each pixel location, the description information about the rate that the field of the configuration of the field of the configuration of a leather slot, area, a direction, the depth, width of face, die length, the description information about a number, or the intersection field of a leather slot and the pore of a there exist, the depth of pore, or magnitude etc. can be evaluated in a detail.

[0022]
[Example] Hereafter, it explains to a detail per example of this invention, referring to a drawing.

<Configuration of skin surface type-like feature-extraction equipment> drawing 1 is the block diagram of the feature-extraction equipment of the shape of skin surface type by this invention.

[0023] First, the replica side 1 carries out templating of the skin front face by silicone rubber etc., and is the surface part of a skin surface replica (negative replica). 1st light source 2A, the 2nd light source 2B, and 3rd light source 2C illuminate the replica side 1 alternatively, and lighting bearing is mutually shifted for the elevation angle by a unit of 120 degrees 30 degrees.

[0024] A switch 6 is controlled by CPU8 through a bus 7, and makes a sequential selection target turn on 1st light source 2A, the 2nd light source 2B, and 3rd light source 2C. The expansion optical system 3 is constituted by a low scale-factor microscope or the close-up photography lens, and it is constituted so that the replica side image of a

predetermined scale factor may be obtained.

[0025] Image pick-up equipment 4 is a CCD image sensor, scans the replica side image obtained through the expansion optical system 3, and generates the analog electrical signal with which the amplitude changes according to the lightness of each pixel location.

[0026] A/D converter 5 changes into digital image data the analog electrical signal generated from image pick-up equipment 4. Including the semiconductor memory which is main storage, memory 9 can also be constituted so that a hard disk drive unit or optical-magnetic disc equipment etc. which is an auxiliary storage unit may be included according to the amount of image data storages.

[0027] Are a microprocessor, for example and first CPU8 by [which control the whole equipment according to the control program memorized by ROM9] controlling a switch 6 through a bus 7 Sequential lighting of the replica side 1 is carried out by 1st light source 2A, the 2nd light source 2B, and 3rd light source 2C, and the digital image data of three sheets obtained from A/D converter 5 corresponding to each lighting actuation are incorporated one by one in memory 9 through a bus 7.

[0028] Next, from the lightness value of each pixel of the digital image data of three sheets incorporated in memory 9, CPU8 calculates the gradient (inclination) of the replica side 1 in each pixel location of a replica side image, and stores the count result in memory 9.

[0029] Then, CPU8 is outputted to a printer 12 or CRT display 12 while it extracts the various feature parameters about the three-dimension configuration on the front face of the skin and memorizes the feature parameter in memory 9 based on the above-mentioned gradient obtained by memory 9.

[0030] Moreover, a user can perform various directions from a keyboard 10 to CPU8. In <principle of three-dimension configuration restoration> this invention, it makes it possible to acquire the depth information in each location of the replica side 1, i.e., to restore the three-dimension configuration of the replica side 1, by obtaining the gradient (inclination) in each location of the replica side 1.

[0031] Then, before explaining concrete actuation of the feature-extraction equipment of the shape of skin surface type which has an above-mentioned configuration, the principle of three-dimension configuration restoration is explained.

It is surface normal vector n (an underline shows that the notation to which it was given is vector quantity.) about the unit vector which defines the xyz coordinate of a three dimension as the replica side 1 is shown in drawing 2 now [of the image pick-up direction / decision], and has a direction perpendicular to the minute field concerned in the minute field of the arbitration on the replica side 1. below the same. the unit vector which has the direction which tends the unit vector which has the direction which tends toward the one light source from the minute field concerned toward the focus of the camera which picturizes it from the direction vector ns of the light source, and the minute field concerned ── the image pick-up direction vector n0 ** ── it carries out. Moreover, the direction vector ns of the light source They are an angle of incidence i and the image pick-up direction vector n0 about the angle which surface normal vector n makes. They are angle of reflection e and the image pick-up direction vector n0 about the angle which surface normal vector n makes. The direction vector ns of the light source The angle to make is used as the phase angle g.

[0032] In addition, in this example, since the replica side 1 is a negative replica side, a leather slot is expressed as a configuration which rises to above [of a drawing], and the direction of the hide depth of flute turns into the direction of −z.

[0033] Now, the replica side 1 assumes that it is an ideal scattered reflection side (called a lambert side). Since a skin surface replica carries out templating of the skin front face by silicone rubber, it can be assumed that the replica side 1 is fully equipped with the property as a lambert side.

[0034] In this case, the reflectivity of the light in the minute field of the arbitration on the replica side 1 is the cosine of the incident angle i of the incident light (uniform light) from the light source. It is proportional only to cosi. That is, the minute field of the arbitration on the replica side 1 which can be assumed to be a lambert side is picturized by the same brightness even if the minute field concerned is picturized by which angle of reflection e. Although the quantity of light with which this is reflected in per unit area in respect of [1] a replica decreases in proportion to the cosine value of angle of reflection e, it is because the surface area of the minute field concerned picturized within the solid angle of a certain arbitration increases in inverse proportion to the cosine value of angle of reflection e, so the brightness of the minute field concerned picturized is not based on the angle of reflection e which shows the image pick-up direction but becomes fixed as a result.

[0035] Therefore, what is necessary is not to take into consideration the angle of reflection e over each point, and just to define the optical axis of the expansion optical system 3 of drawing 1 in the direction which intersects perpendicularly mostly to the field in which the replica side 1 is established, in picturizing each point of the replica side 1 which can be assumed to be a lambert side.
What is necessary is just to be able to ask for the gradient (inclination) of the replica side 1 in each pixel location of the replica side image which picturized and acquired the replica side 1, in order to restore the three-dimension configuration of the related replica side 1 of a gradient and a surface normal vector. It is because the three-dimension configuration of the replica side 1 can be restored by integrating with them in the fixed direction if it can ask for the gradient in each pixel location.

[0036] Now, the replica side 1 in the xyz coordinate defined by drawing 2 is expressed with a degree type.

[0037]
[Equation 1]
$$z = f(x, y)$$

[0038] Each element can express the gradient of the replica side 1 expressed with this formula by the vector (p, q) shown by the degree type.

[0039]
[Equation 2]

$$p = \frac{\partial (z)}{\partial x}$$

$$q = \frac{\partial (z)}{\partial y}$$

[0040] Here, the minute field of the arbitration on the replica side 1 in the xyz coordinate shown in <u>drawing 2</u> can be approximated at the flat surface shown by the degree type.

[0041]

[Equation 3]

$$A x + B y + C z + D = 0$$

$$\therefore z = - \frac{A}{C} x - \frac{B}{C} y - \frac{D}{C}$$

[0042] From a formula 2 and a formula 3, the elements p and q of the gradient in the minute field concerned can be expressed with a degree type.

[0043]

[Equation 4]

$$p = \frac{\partial}{\partial x} (- \frac{A}{C} x - \frac{B}{C} y - \frac{D}{C}) = - \frac{A}{C}$$

$$q = \frac{\partial}{\partial y} (- \frac{A}{C} x - \frac{B}{C} y - \frac{D}{C}) = - \frac{B}{C}$$

[0044] Therefore, the flat surface of the minute field concerned is expressed with a degree type from a formula 3 and a formula 4.

[0045]

[Equation 5]

$$z = p x + q y + K$$

（K：定数）

[0046] Now predetermined point (0 0K) In order to satisfy the equation of a formula 5, this point is a point on the flat surface of the minute field concerned. And point of the arbitration on the flat surface of this point to the minute field concerned (x y, z) Vector (x, y, z-k) Since it intersects perpendicularly with surface normal vector n of the minute field concerned, the inner product of these vectors is 0.

[0047] Here, at <u>drawing 2</u> , since surface normal vector n is a vector which goes in the direction of -z, it can be expressed with a degree type.

[0048]

[Equation 6]

$$\underline{n} = (n_1, n_2, -n_3)$$

[0049] However, it is n3 >0. Vector on surface normal vector n shown with a formula 6, and a minute field (x, y, z-k) A degree type is materialized from an inner product being 0.

[0050]
[Equation 7]
$$(x, y, z - K) \cdot (n_1, n_2, -n_3)$$
$$= n_1 x + n_2 y - n_3 (z - K) = 0$$
$$\therefore \quad z = \frac{n_1}{n_3} + \frac{n_2}{n_3} + K$$

[0051] A degree type is materialized from a formula 5 and a formula 7.
[0052]
[Equation 8]
$$p = n_1 / n_3$$
$$q = n_2 / n_3$$

[0053] Therefore, from the relation of a formula 8, if it can ask for surface normal vector
n= (n1, n2, and −n3) in each minute field on the replica side 1, it can ask for the gradient
(p, q) in the minute field concerned.
[0054] Here, it is each pixel location (x y) of a replica side image about each minute field
on the replica side 1. It is made to correspond, and the gradient in the location is set to (p
(x y) and q (x y)), and a surface normal vector is expressed with a degree type from a
formula 6.
[0055]
[Equation 9]
$$\underline{n\ (x,y)} = (n_1(x,y), n_2(x,y), -n_3(x,y))$$

[0056] However, since surface normal vector n is a unit vector, a degree type is
materialized.
[0057]
[Equation 10]
$$n_1(x,y)^2 + n_2(x,y)^2 + n_3(x,y)^2 = 1$$
$$\therefore \quad n_3 = \{1 - n_1(x,y)^2 - n_2(x,y)^2\}^{1/2}$$

[0058] A degree type is materialized from a formula 8, a formula 9, and a formula 10.
[0059]
[Equation 11]
$$p\,(x,y) = n_1(x,y) / \{1 - n_1(x,y)^2 - n_2(x,y)^2\}^{1/2}$$
$$q\,(x,y) = n_2(x,y) / \{1 - n_1(x,y)^2 - n_2(x,y)^2\}^{1/2}$$

[0060] Therefore, it is each pixel location (x y) of a replica side image from the relation of
a formula 11. Surface normal vector n (x y) If it can ask, it can ask for the gradient (p (x
y) and q (x y)) in the location. And if it integrates with the gradient in each pixel location
in the fixed direction of a pixel, the value of a z-coordinate can be presumed for every

pixel location, and the three-dimension configuration of the replica side 1 can be restored.

presumption of the surface normal vector in each pixel location — the reflectivity of the light in the minute field of the arbitration on the replica side 1 if the replica side 1 is assumed to be a lambert side as mentioned above — cosine of the incident angle i of the incident light (uniform light) from the light source It is proportional only to cosi. The same relation is materialized also on a replica side image, and it is each pixel $(x\ y)$. Reflectivity R of the light which can be set $(x\ y)$ Cosine of the incident angle i of the incident light from the light source $(x\ y)$ cosi $(x\ y)$ A degree type is materialized proportionally therefore.

[0061]
[Equation 12]
$$R(x,y) = r_0(x,y)\cos i(x,y)$$

[0062] However, $r_0(x\ y)$ Pixel location $(x\ y)$ It is a reflection factor in the corresponding replica side 1. If the one direction vector ns (it is not dependent on a pixel location $(x\ y)$) of the light source is determined now, a degree type will be materialized from the relation shown in <u>drawing 2</u> .

[0063]
[Equation 13]
$$\cos i(x,y) = \underline{n_s \cdot n(x,y)}$$

[0064] Therefore, a degree type is materialized from a formula 12 and a formula 13.
[0065]
[Equation 14]
$$R(x,y) = r_0(x,y) \ \{\underline{n_s \cdot n(x,y)}\}$$

[0066] Each pixel location which actually picturizes the replica side 1 here and is obtained $(x\ y)$ It is I $(x\ y)$ about a lightness value. Then, the following equation is materialized.
[0067]
[Equation 15]
$$I(x,y) = c(x,y) \ R(x,y)$$

[0068] However, c $(x\ y)$ Pixel location $(x\ y)$ It is a normalization constant. Therefore, the following equation is materialized from a formula 14 and a formula 15.
[0069]
[Equation 16]
$$I(x,y) = \alpha(x,y) \ \{\underline{n_s \cdot n(x,y)}\}$$

[0070]
[Equation 17]
$$\alpha(x,y) = c(x,y) \ r_0(x,y)$$

[0071] It sets to a formula 16 and is alpha $(x\ y)$. Surface normal vector n $(x\ y)$ It is an

unknown and is n (x y) from a formula 9 and a formula 10. Two unknowns n1 (x y) n2 (x y) It contains. Therefore, in order to determine these unknowns including three unknowns, three equations are required for a formula 16.

[0072] Then, 1st light source 2A arranged in the three directions as shown in <u>drawing 1</u>, Each pixel location which illuminates the replica side 1 separately by the 2nd light source 2B and 3rd light source 2C, actually picturizes the replica side 1 corresponding to the lighting from each light source, and is obtained (x y) Three lightness values, It is a multiplier alpha (x y) by solving the equation of a formula 16 about the direction vector of the light source of the three above-mentioned light sources. And surface normal vector n (x y) It can determine.

[0073] First, since the three direction vectors ns1, ns2, and ns3 of the light source are unit vectors which go in the direction of -z, respectively, the same idea as a formula 6 and a formula 10 can express them in procession N of a degree type.

[0074]

[Equation 18]

$$N = \begin{pmatrix} \underline{n_{s1}} \\ \underline{n_{s2}} \\ \underline{n_{s3}} \end{pmatrix} = \begin{pmatrix} n_{s11}, n_{s12}, & -(1-n_{s11}{}^2 - n_{s12}{}^2)^{1/2} \\ n_{s21}, n_{s22}, & -(1-n_{s21}{}^2 - n_{s22}{}^2)^{1/2} \\ n_{s31}, n_{s32}, & -(1-n_{s31}{}^2 - n_{s32}{}^2)^{1/2} \end{pmatrix}$$

[0075] Moreover, each pixel location (x y) Three lightness values I1 (x y) which can be set, I2 (x y), and I3 (x y) Transposition vector I of a degree type (x y) It expresses.

[0076]

[Equation 19]

$$\underline{I(x,y)} = (I_1(x,y), I_2(x,y), I_3(x,y))^T$$

[0077] However, T of the right shoulder of the parenthesis of the right-hand side of a formula 19 shows transposition. A degree type is materialized from a formula 16, a formula 18, and a formula 19.

[0078]

[Equation 20]

$$\underline{I(x,y)} = \alpha(x,y) \, N \underline{n(x,y)}$$

[0079] If the three direction vectors ns1, ns2, and ns3 of the light source cannot be found on the same flat surface, the inverse matrix N-1 of the matrix N shown with a formula 18 exists. Then, it is surface normal vector n (x y) first. It being a unit vector, and a formula 18 and a formula 19 are used, and it is a multiplier alpha (x y). It can ask by the degree type.

[0080]

[Equation 21]

$$\alpha(x,y) = |N^{-1} \underline{I(x,y)}|$$

[0081] Furthermore, the multiplier alpha (x y) which was able to be found with the formula 21, a formula 9, a formula 10, a formula 18, and a formula 19 are used, and it is surface normal vector n (x y). It can ask by the degree type.

[0082]
[Equation 22]

$$n(x,y) = \frac{1}{\alpha(x,y)} N^{-1} I(x,y)$$

[0083] It is each pixel location (x y) at the presumed formula 22 of the gradient in each pixel location. Surface normal vector n (x y) If it can be found, it is each pixel location (x y) by the formula 11. It can ask for a gradient (p (x y) and q (x y)).
The gradient (p (x y) and q (x y)) presumed based on the correction above-mentioned principle of the gradient by the relaxation method is each pixel location (x y) of the replica side image which actually picturizes the replica side 1 and is obtained corresponding to the lighting from the three light sources. Since it is the value presumed from three lightness values, many errors are included. Each pixel location (x y) Error E (x y) A definition can be given like a degree type.
[0084]
[Equation 23]

$$E(x,y) = s_e(x,y) + r_e(x,y)$$

[0085] It sets to a formula 23 and is se (x y) first. Pixel location (x y) The error of the smoothness of the replica side 1 which can be set is shown, and it defines as a degree type.
[0086]
[Equation 24]

$$s_e(x,y) = \frac{1}{4} \{p_x(x,y)^2 + p_y(x,y)^2 + q_x(x,y)^2 + q_y(x,y)^2\}$$

[0087] Here, px (x y) is a gradient p (x y). It is the primary partial differential of the direction of an x-coordinate, and is px (x y)2. Gradient p (x y) The square error of the direction of an x-coordinate is shown. If this value is small, it is a gradient p (x y). The smooth thing is shown in the direction of an x-coordinate. Similarly, it is py (x y) and py (x y)2. Gradient p (x y) The primary partial differential and square error of the direction of a y-coordinate are shown. qx (x y) and qx (x y)2 Gradient q (x y) The primary partial differential and square error of the direction of an x-coordinate are shown, and it is qy (x y) and qy (x y)2. Gradient q (x y) The primary partial differential and square error of the direction of a y-coordinate are shown.
[0088] The replica side 1 corresponding to a skin front face is the error [in / after all / since there is a heuristics request of being smooth, locally / a formula 23] se (x y). If small, it is a pixel location (x y). It will set and the conditions that the replica side 1 is smooth will be satisfied.
[0089] next, the formula 23 -- setting -- re (x y) Pixel location (x y) Three lightness values corresponding to the three directions of the light source which set, actually picturize the replica side 1 and are acquired, The linear combination of a square error with the reflectivity of three normalized light corresponding to the three directions of the light source calculated based on the gradient (p (x y) and q (x y)) obtained by

presumption is shown, and if based on the equation of a formula 15, it will define as a degree type.

[0090]

[Equation 25]

$$r_e(x,y) = \lambda_1 \{ I_1(x,y) - c(x,y) R_1(x,y)$$

$$+ \lambda_2 \{ I_2(x,y) - c(x,y) R_2(x,y)$$

$$+ \lambda_3 \{ I_3(x,y) - c(x,y) R_3(x,y)$$

[0091] here -- I1 (x y), I2 (x y), and I3 (x y) Pixel location (x y) They are three lightness values corresponding to the three directions of the light source which set, actually picturize the replica side 1 and are acquired (formula 19 reference). c (x y)R1 (x y), c (x y)R2 (x y), and c (x y)R3 (x y) [moreover,] Pixel location (x y) Multiplier alpha which sets and is presumed by the formula 21 (x y) It is the reflectivity of three normalized light corresponding to the three directions of the light source calculated based on the gradient (p (x y) and q (x y)) presumed by the formula 22. Moreover, lambda 1, lambda 2, and lambda 3 Error E of the square error term of each light source direction where the multiplication of each is carried out (x y) It is the constant which appoints the receiving contribution and is set experientially, respectively.

[0092] error re (x y) in a formula 23 if fully small, the equation about the reflection factor shown with the formula 15 mentioned above will be materialized -- ******** -- the estimate of a gradient (p (x y) and q (x y)) -- the right -- it becomes things.

[0093] pixel location (x y) every -- error E (x y) defined by formulas 23-25 in order to make it min -- error E (x y) Gradient p (x y) A degree type will be obtained if the obtained formula which carried out the partial differential is set with 0.

[0094]

[Equation 26]

$$\frac{\partial E(x,y)}{\partial p(x,y)} = \frac{\partial s_e(x,y)}{\partial p(x,y)} + \frac{\partial r_e(x,y)}{\partial p(x,y)} = 0$$

[0095] The 1st term of the right-hand side of a formula 26 is calculated like a degree type from a formula 24.

[0096]

[Equation 27]

$$\frac{\partial s_e(x,y)}{\partial p(x,y)} = \frac{1}{4}\left(\frac{\partial\{p_x(x,y)^2\}}{\partial p(x,y)} + \frac{\partial\{p_y(x,y)^2\}}{\partial p(x,y)} + 0 + 0\right)$$

$$= \frac{1}{4}\left(\frac{\partial\{p_x(x,y)^2\}}{\partial x}\cdot\frac{\partial x}{\partial p(x,y)} + \frac{\partial\{p_y(x,y)^2\}}{\partial y}\cdot\frac{\partial y}{\partial p(x,y)}\right)$$

$$= \frac{1}{4}\left\{2p_x(x,y)\ p_{xx}(x,y)\ \frac{1}{p_x(x,y)}\right.$$

$$\left. + 2p_y(x,y)\ p_{yy}(x,y)\ \frac{1}{p_y(x,y)}\right\}$$

$$= 2\times\frac{1}{4}\left\{p_{xx}(x,y) + p_{yy}(x,y)\right\}$$

[0097] Here, it is pxx (x y). Pixel location (x y) Gradient p (x y) The secondary partial differential of the direction of an x-coordinate, and pyy (x y) Pixel location (x y) Gradient p (x y) It is the secondary partial differential of the direction of a y-coordinate, and is shown by the degree type in approximation, respectively.
[0098]
[Equation 28]

$$p_{xx}(x,y) = \{p(x+1,y) - p(x,y)\} - \{p(x,y) - $$

$$p_{yy}(x,y) = \{p(x,y+1) - p(x,y)\} - \{p(x,y) - $$

[0099] namely, pxx (x y) approximation ---like -- pixel location (x y) Gradient p (x y) pixel location (x y) Pixel location (x+1, y) which adjoins in the x directions And (x-1, y) Gradient p (x+1, y) And p (x-1, y) A value is calculated. respectively -- ** -- difference -- two obtained difference -- a value -- further -- difference -- it can ask by calculating a value. pyy about the direction of y (x y) Even if it attaches, it can ask similarly.
[0100] A degree type is obtained from a formula 27 and a formula 28.
[0101]
[Equation 29]

$$\frac{\partial s_e(x,y)}{\partial p(x,y)} = 2 \times \frac{1}{4}\left\{ 4p_{av}(x,y) - 4p(x,y) \right.$$

$$= 2 \times \left\{ p_{av}(x,y) - p(x,y) \right\}$$

[0102] However, pav (x y) It is a pixel location (x y) so that it may be expressed with a degree type. It is the average of the gradient in four pixel locations which adjoin four directions.

[0103]

[Equation 30]

$$p_{av}(x,y) = \frac{1}{4}\left\{ p(x+1,y) + p(x-1,y) + p(x,y+1) + p(x,y-1) \right\}$$

[0104] On the other hand, the 2nd term of the right-hand side of a formula 26 mentioned above is calculated like a degree type from a formula 25.

[0105]

[Equation 31]

$$\frac{\partial r_e(x,y)}{\partial p(x,y)} = \frac{\partial}{\partial p(x,y)} \left[\lambda_1 \{ I_1(x,y) - c(x,y) R_1(x,y) \}^2 \right]$$

$$+ \frac{\partial}{\partial p(x,y)} \left[\lambda_2 \{ I_2(x,y) - c(x,y) R_2(x,y) \}^2 \right]$$

$$+ \frac{\partial}{\partial p(x,y)} \left[\lambda_3 \{ I_3(x,y) - c(x,y) R_3(x,y) \}^2 \right]$$

$$= 2\lambda_1 \left\{ I_1(x,y) - c(x,y) R_1(x,y) \right\} \frac{\partial \{ -c(x,y) R_1(x,y) \}}{\partial p(x,y)}$$

$$+ 2\lambda_2 \left\{ I_2(x,y) - c(x,y) R_2(x,y) \right\} \frac{\partial \{ -c(x,y) R_2(x,y) \}}{\partial p(x,y)}$$

$$+ 2\lambda_3 \left\{ I_3(x,y) - c(x,y) R_3(x,y) \right\} \frac{\partial \{ -c(x,y) R_3(x,y) \}}{\partial p(x,y)}$$

$$= -2 \left[\lambda_1 \left\{ I_1(x,y) - c(x,y) R_1(x,y) \right\} \frac{\partial \{ c(x,y) R_1(x,y) \}}{\partial p(x,y)} \right.$$

$$+ \lambda_2 \left\{ I_2(x,y) - c(x,y) R_2(x,y) \right\} \frac{\partial \{ c(x,y) R_2(x,y) \}}{\partial p(x,y)}$$

$$\left. + \lambda_3 \left\{ I_3(x,y) - c(x,y) R_3(x,y) \right\} \frac{\partial \{ c(x,y) R_3(x,y) \}}{\partial p(x,y)} \right]$$

[0106] The following equation is materialized from a formula 26, a formula 29, and a formula 31.

[0107]

[Equation 32]

$$2 \times \{ p_{av}(x,y) - p(x,y) \}$$

$$- 2 \left[\lambda_1 \left\{ I_1(x,y) - c(x,y) R_1(x,y) \right\} \right.$$

$$+ \lambda_2 \left\{ I_2(x,y) - c(x,y) R_2(x,y) \right\} \frac{\partial \{}{}$$

$$+ \lambda_3 \left\{ I_3(x,y) - c(x,y) R_3(x,y) \right\} \frac{\partial \{}{}$$

$$= 0$$

[0108] Therefore, gradient p (x y) It is corrected by the degree type.

[0109]

[Equation 33]

$$p(x,y) = p_{av}(x,y)$$

$$- \lambda_1 \left\{ I_1(x,y) - c(x,y) R_1(x,y) \right\} \frac{\partial \{c(x,y) R_1(x,y)\}}{\partial p(x,y)}$$

$$- \lambda_2 \left\{ I_2(x,y) - c(x,y) R_2(x,y) \right\} \frac{\partial \{c(x,y) R_2(x,y)\}}{\partial p(x,y)}$$

$$- \lambda_3 \left\{ I_3(x,y) - c(x,y) R_3(x,y) \right\} \frac{\partial \{c(x,y) R_3(x,y)\}}{\partial p(x,y)}$$

[0110] At a formula 33, it is pav (x y). It is a pixel location (x y) so that it may be expressed with a formula 30. It is calculable as the average of the gradient in four pixel locations which adjoin four directions.

[0111] Next, it is a constant lambda 1, lambda 2, and lambda 3 at a formula 33. As mentioned above, it is set experientially. moreover, the formula 33 -- I1 (x y), I2 (x y), and

13 (x y) As mentioned above, it is a pixel location (x y). They are three lightness values corresponding to the three directions of the light source which set, actually picturize the replica side 1 according to 1st light source 2A of <u>drawing 1</u> , the 2nd light source 2B, and the three light sources of 3rd light source 2C, and are acquired.

[0112] furthermore, the formula 33 -- setting -- c (x y)R1 (x y) a formula 14 and a formula 17 -- it is further expressed by the degree type from a formula 18, a formula 9, and a formula 10.

[0113]

[Equation 34]

$$c(x,y) \ R_1(x,y) = \alpha(x,y) \ \{\underline{n_{s1}} \cdot \underline{n(x,y)}\}$$

$$= \alpha(x,y) \ (n_{s11}, n_{s12}, -(1 - n_{s11}^2 - n_{s12}$$

$$\cdot (n_1(x,y), n_2(x,y), -\{1 - n_1(x,$$

$$= \alpha(x,y) \ (n_{s11} \ n_1(x,y) + n_{s12} \ n_2(x,y) +$$

$$\times \{1 - n_1(x,y)^2 - n_2(x,y)^2\}^{1/2} \ )$$

[0114] Here, a degree type is materialized from a formula 11.

[0115]

[Equation 35]

$$p(x,y)^2 + q(x,y)^2 + 1 = n_1(x,y)^2 / \{1 - n_1(x,y)^2 - n_2(x,y)^2\}$$

$$+ n_2(x,y)^2 / \{1 - n_1(x,y)^2 - n_2(x,y)^2\}$$

$$+ 1$$

$$= 1 / \{1 - n_1(x,y)^2 - n_2(x,y)^2\}$$

$$\therefore \{1 - n_1(x,y)^2 - n_2(x,y)^2\}^{1/2} = 1 / \{p(x,y)^2 + q(x,y)^2\}^{1/2}$$

[0116] A degree type is obtained by substituting a formula 35 for a formula 11.

[0117]

[Equation 36]

$$n_1(x,y) = p(x,y) / \{p(x,y)^2 + q(x,y)^2 + 1\}^{1/2}$$

$$n_2(x,y) = p(x,y) / \{p(x,y)^2 + q(x,y)^2 + 1\}^{1/2}$$

[0118] Term [in / from a formula 34 and a formula 36 / a formula 33] c (x y)R1 (x y) The element ns11 of the direction vector ns1 of the light source, and ns12 Pixel location (x y) Multiplier alpha which can be set (x y) And it is calculable with a degree type using a

gradient (p (x y) and q (x y)).

[0119]

[Equation 37]

$c(x,y) \ R_1 (x,y)$

$$= \alpha(x,y) \frac{\{n_{s11} \ p(x,y) + n_{s12} \ q(x,y) + (1 - n_{s11}^2 - n_{s12}^2)^{1/2}}{\{p(x,y)^2 + q(x,y)^2 + 1\}^{1/2}}$$

$$= \alpha(x,y) \ W_1 / G^{1/2}$$

[0120]

[Equation 38]

$G = p(x,y)^2 + q(x,y)^2 + 1$

[0121]

[Equation 39]

$$W_1 = n_{s11} \ p(x,y) + n_{s12} \ q(x,y) + (1 - n_{s1}$$

[0122] Term [in / completely like a formula 37 / a formula 33] c (x y)R2 (x y) The
element ns21 of the direction vector ns2 of the light source, and ns22 Pixel location (x y)
It is calculable with a degree type and a formula 38 using the multiplier alpha (x y) which
can be set, and a gradient (p (x y) and q (x y)).

[0123]

[Equation 40]

$c(x,y) \ R_2(x,y)$

$$= \alpha(x,y) \frac{\{n_{s21} \ p(x,y) + n_{s22} \ q(x,y) + (1 - n_{s21}^2 - n_{s22}^2)^{1/2}\}}{\{p(x,y)^2 + q(x,y)^2 + 1\}^{1/2}}$$

$$= \alpha(x,y) \ W_2 / G^{1/2}$$

[0124]

[Equation 41]

$W_2 = n_{s21} \ p(x,y) + n_{s22} \ q(x,y) + (1 - n_{s21}^2 - n_{s22}^2)^{1/2}$

[0125] Term [in / similarly / a formula 33] c (x y)R3 (x y) The element ns31 of the
direction vector ns3 of the light source, and ns32 Pixel location (x y) Multiplier alpha
which can be set (x y) And it is calculable with a degree type and a formula 38 using a
gradient (p (x y) and q (x y)).

[0126]

[Equation 42]

$$c(x, y) \ R_3(x, y)$$

$$= \alpha(x, y) \ \frac{\{n_{s31} \ p(x, y) + n_{s32} \ q(x, y) + (1 - n_{s31}{}^2 - n_{s32}{}^2)^{1/2}\}}{\{p(x, y)^2 + q(x, y)^2 + 1\}^{1/2}}$$

$$= \alpha(x, y) \ W_3 / G^{1/2}$$

[0127]

[Equation 43]

$$W_3 = n_{s31} \ p(x, y) + n_{s32} \ q(x, y) + (1 - n_{s31}{}^2 - n_{s32}{}^2)^{1/2}$$

[0128] In a formula 33 Furthermore, term **{c (x y)R1 (x y)} / ** p (x y), ** {c (x y)R2 (x y)} /**p (x y), and **{c (x y)R1 (x y)} / **p (x y) It is p (x y) about a formula 37, a formula 40, and a formula 42, respectively. By carrying out a partial differential, it is calculable with the following formulas 44-46 and formulas 38, 39, 41, and 43.

[0129]

[Equation 44]

$$\partial \, \{c(x,y) \, R_1(x,y)\} \,/\, \partial \, p(x,y)$$

$$= \alpha(x,y) \, [n_{s11} \, \{p(x,y)^2 + q(x,y)^2 + 1\}$$

$$- p(x,y) \, \{n_{s11} \, p(x,y) + n_{s12} \, q(x,y) + (1-n$$

$$/ \, \{p(x,y)^2 + q(x,y)^2 + 1\}^{3/2}$$

$$= \alpha(x,y) \, \{n_{s11} \, G - p(x,y) \, W_1\} \,/\, G^{3/2}$$

[0130]
[Equation 45]

$$\partial \{c(x,y) R_2(x,y)\} / \partial p(x,y)$$

$$= \alpha(x,y) \{n_{s21} \{p(x,y)^2 + q(x,y)^2 + 1\}$$

$$- p(x,y) \{n_{s21} p(x,y) + n_{s22} q(x,y) + ($$

$$/ \{p(x,y)^2 + q(x,y)^2 + 1\}^{3/2}$$

$$= \alpha(x,y) \{n_{s21} G - p(x,y) W_2\} / G^{3/2}$$

[0131]

[Equation 46]

$$\partial \{ c(x,y) \; R_3(x,y) \} / \partial p(x,y)$$

$$= \alpha(x,y) \; [n_{s31} \; \{ p(x,y)^2 + q(x,y)^2 + 1 \}$$

$$- p(x,y) \{ n_{s31} \; p(x,y) + n_{s32} \; q(x,y) + (1 -$$

$$/ \{ p(x,y)^2 + q(x,y)^2 + 1 \}^{3/2}$$

$$= \alpha(x,y) \{ n_{s31} \; G - p(x,y) \; W_3 \} / G^{3/2}$$

[0132] As mentioned above, it is a gradient p (x y) by the equation shown with a formula
33 by using a formula 30, formulas 37–43, and formulas 44–46. It is correctable.
[0133] Error E defined by formulas 23–25 on the other hand (x y) It is Error E (x y) like
[in order to make it min] the case of formulas 26–36. Gradient q (x y) A partial
differential is carried out. Consequently, above-mentioned gradient p (x y) It is a gradient
q (x y) by the formulas 37–43 mentioned above like the case, and the equation shown
with the following formula 47 by using the formula 48 shown below and formulas 49–51. It
is correctable.
[0134]
[Equation 47]

$$q(x,y) = q_{av}(x,y)$$

$$-\lambda_1 \left\{ I_1(x,y) - c(x,y) R_1(x,y) \right\} \frac{\partial \{c(x,y) R_1(x,y)\}}{\partial q(x,y)}$$

$$-\lambda_2 \left\{ I_2(x,y) - c(x,y) R_2(x,y) \right\} \frac{\partial \{c(x,y) R_2(x,y)\}}{\partial q(x,y)}$$

$$-\lambda_3 \left\{ I_3(x,y) - c(x,y) R_3(x,y) \right\} \frac{\partial \{c(x,y) R_3(x,y)\}}{\partial q(x,y)}$$

[0135]
[Equation 48]

$$q_{av}(x,y)$$

$$= \frac{1}{4} \left\{ q(x+1,y) + q(x-1,y) + q(x,y+1) + q(x,y-1) \right\}$$

[0136]
[Equation 49]

$$\partial \{c(x,y) R_1(x,y)\} / \partial q(x,y)$$

$$= \alpha(x,y) [n_{s12} \{p(x,y)^2 + q(x,y)^2 + 1\}$$

$$- q(x,y) \{n_{s11} p(x,y) + n_{s12} q(x,y)$$

$$+ (1 - n_{s11}{}^2 - n_{s12}{}^2)^{1/2}\}]$$

$$/ \{p(x,y)^2 + q(x,y)^2 + 1\}^{3/2}$$

$$= \alpha(x,y) \{n_{s12} G - q(x,y) W_1\} / G^{3/2}$$

[0137]
[Equation 50]

$$\partial \{c(x,y) R_2(x,y)\} / \partial p(x,y)$$

$$= \alpha(x,y) \; [n_{sz2} \{p(x,y)^2 + q(x,y)^2 + 1\}$$

$$- q(x,y) \{n_{sz1} p(x,y) + n_{sz2} q(x,y) + (1$$

$$/ \{p(x,y)^2 + q(x,y)^2 + 1\}^{3/2} \}$$

$$= \alpha(x,y) \; \{n_{sz2} G - q(x,y) W_2\} / G^{3/2}$$

[0138]

[Equation 51]

$$\partial \{ c(x,y) \, R_3(x,y) \} / \partial p(x,y)$$

$$= \alpha(x,y) \; [\, n_{s32} \{ p(x,y)^2 + q(x,y)^2 + 1 \}$$

$$- q(x,y) \{ n_{s31} \, p(x,y) + n_{s32} \, q(x,y) + (1$$

$$/ \{ p(x,y)^2 + q(x,y)^2 + 1 \}^{3/2}$$

$$= \alpha(x,y) \{ n_{s32} \, G - q(x,y) \, W_3 \} / G^{3/2}$$

[0139] gradient p (x y) shown with an above-mentioned formula 33 and an above-mentioned formula 47 and the correction equation of q (x y) ── pav (x y) of the right-hand side, qav (x y), R1 (x y), R2 (x y), and R3 (x y) It is materialized when calculated based on the gradient of a signed off. However, the gradient of a signed off does not exist in the initial state immediately after presuming a gradient in each pixel location.

[0140] Then, a relaxation method is adopted as correction of a gradient in the example of this invention. Namely, pav (x y) calculated considering the estimate of a gradient as initial value, qav (x y), R1 (x y), R2 (x y), and R3 (x y) By calculating a formula 33 and a formula 47 by being based Each pixel location (x y) A gradient (p (x y) and q (x y)) is corrected. pav (x y) qav (x y) calculated from the corrected gradient, R1 (x y), R2 (x y), and R3 (x y) It is based. With a formula 33 and a formula 47 Each pixel location (x y) Gradient p (x y) And q (x y) Processing in which it modifies is repeated.

[0141] Consequently, each pixel location (x y) A gradient (p (x y) and q (x y)) is gradually converged on an appropriate value. the gradient (p (x y) ──) corrected last time in advance of each repeat at this time It is based on q (x y) and is each pixel location (x y) by the formula 23. Error E (x y) What is necessary is just to judge with having been

completed by the value of a gradient (p (x y) and q (x y)), when it calculates and the sum of all the pixels of this error becomes small enough.

[0142] In addition, error E of a formula 23 (x y) It sets to count and is se (x y). It can calculate with a formula 24 and px (x y), py (x y), qx (x y), and qy (x y) can be calculated by the degree type at this time.

[0143]

[Equation 52]

$$p_x \ (x, y) = p \ (x+1, y) - p \ (x-1, y)$$

$$p_y \ (x, y) = p \ (x, y+1) - p \ (x, y-1)$$

$$q_x \ (x, y) = q \ (x+1, y) - q \ (x-1, y)$$

$$q_y \ (x, y) = q \ (x, y+1) - q \ (x, y-1)$$

[0144] Moreover, error E of a formula 23 (x y) It sets to count and is re (x y). It is calculable with a formula 25. it mentioned above at this time — as — I1 (x y), I2 (x y), and I3 (x y) As mentioned above, it is a pixel location (x y). It sets. The replica side 1 1st light source 2A of drawing 1 , They are three lightness values corresponding to the three directions of the light source which actually picturize according to the 2nd light source 2B and the three light sources of 3rd light source 2C, and are acquired. lambda 1, lambda 2, and lambda 3 are constants defined experientially, respectively, and are c (x y)R1 (x y), c (x y)R2 (x y), and c (x y)R3 (x y). It is calculable with formulas 37–43.

About concrete actuation of the feature-extraction equipment of the shape of skin surface type of drawing 1 based on the principle of the <concrete actuation of feature-extraction equipment of shape of skin surface type by this invention> above-mentioned three-dimension configuration restoration, sequential explanation is given below. In addition, the following operation flow charts are realized as actuation which performs the control program with which CPU8 of drawing 1 was memorized by ROM10.

Whole actuation drawing 3 is an operation flow chart which shows overall processing of skin surface type-like feature-extraction equipment.

[0145] First, at step S301, the replica side image of three sheets is inputted and it is incorporated by memory 9. Next, each pixel location of the lightness value of each pixel location of the digital image data of three sheets incorporated by memory 9 at step S302 to a replica side image (x y) The gradient (p (x y) and q (x y)) of the replica side 1 is calculated.

[0146] And a skin surface type-like feature parameter is extracted from an above-mentioned gradient (p (x y) and q (x y)) at step S303.

Input drawing 4 of a replica side image is the operation flow chart of the input process of the replica side image of step S301 of drawing 3 .

[0147] First, CPU8 controls a switch 6 by step S401 through a bus 7, and makes 1st light source 2A turn on at it. Next, the digital image data obtained from A/D converter 5 are incorporated one by one to the 1st image storing field of memory 9 through a bus 7 at step S402.

[0148] Next, CPU8 controls a switch 6 by step S403 through a bus 7, and makes the 2nd light source 2B turn on at it. And the digital image data obtained from A/D converter 5 are incorporated one by one to the 2nd image storing field of memory 9 through a bus 7 at step S404.

[0149] Furthermore, CPU8 controls a switch 6 by step S405 through a bus 7, and makes 3rd light source 2C turn on at it. And the digital image data obtained from A/D converter 5 are incorporated one by one to the 3rd image storing field of memory 9 through a bus 7 at step S406.

[0150] the above processing -- memory 9 -- each pixel location (x y) of the image pick-up field on the replica side 1 every -- three lightness values I1 (x y), I2 (x y), and I3 (x y) Data are obtained.

Count drawing 5 of the gradient in each pixel location is each pixel location of a replica side image of step S302 of drawing 3 (x y). It is the operation flow chart of the computation of the gradient (p (x y) and q (x y)) of the replica side 1.

[0151] First, it is each pixel location (x y) by calculating a formula 21 at step S501 using a formula 18 and a formula 19. Multiplier alpha (x y) It is presumed. In addition, the three direction vectors ns1, ns2, and ns3 of the light source shown with a formula 18 can be determined when 1st light source 2A, the 2nd light source 2B, and 3rd light source 2C are installed, and they are beforehand memorized by memory 9. moreover, each pixel location (x y) shown with a formula 19 Three lightness values I1 (x y), I2 (x y), and I3 (x y) processing of step S303 (refer to drawing 4) of drawing 3 -- the 1- of memory 9 -- it is obtained to the 3rd image field.

[0152] Next, each pixel location obtained at step S501 by step S502 (x y) Multiplier alpha (x y) It is each pixel location (x y) by calculating a formula 22 using a formula 9, a formula 10, a formula 18, and a formula 19. Surface normal vector n (x y) It is presumed.

[0153] Next, each pixel location which was able to be found at step S502 in step S503 (x y) Surface normal vector n (x y) It is based and is each pixel location (x y) by the formula 11. A gradient (p (x y) and q (x y)) is presumed.

[0154] Then, processing of the relaxation method of steps S504-S509 is performed. First, each pixel location which was able to be found at step S503 in step S504 (x y) A gradient (p (x y) and q (x y)) is p (x y) and q (x y) of the repeat operation of a relaxation method. As initial value, it is set as the suitable variable area of memory 9.

[0155] next, the step S505 -- an above-mentioned gradient (p (x y) --) the last value (the initial value to which it was set at step S504 in the case of the first time --) of q (x y) Based on the value calculated at steps S508 and S509, it is each pixel location (x y) after it by calculating a formula 23 using a formula 24, a formula 52, a formula 25, and formulas 37-43. Error E (x y) It is calculated. Here, the right-hand side of a formula 52 is each pixel location (x y). It is calculated based on the last value of the gradient in four pixel locations which adjoin four directions. Moreover, the value of the last time [the right-hand side of a formula 38 is calculated based on the last value of a gradient (p (x y) and q (x y)), and / right-hand side / of formulas 39, 41, and 43] of a gradient (p (x y) and q (x y)), It is calculated based on each element of the three direction vectors ns1, ns2, and ns3 of the light source beforehand memorized by memory 9. Further the right-hand side of formulas 37, 40, and 42 The count result of the above-mentioned formulas 38, 39, 41, and 43, and multiplier alpha calculated at step S501 (x y) It is based and calculated. moreover, the formula 25 -- a constant lambda 1, lambda 2, and lambda 3 it is determined experientially that it mentioned above and it obtains in memory 9 beforehand -- having -- **** -- I1 (x y), I2 (x y), and I3 (x y) -- processing of step S303 (refer to drawing 4) of drawing 3 -- the 1- of memory 9 -- it is obtained to the 3rd image field.

[0156] Then, each pixel location calculated at step S505 in step S506 (x y) Error E (x y) The total about all pixels is calculated. And at step S507, it is judged whether total of the error calculated at step S506 became below a predetermined threshold.

[0157] If the judgment of step S507 is NO, a gradient (p (x y) and q (x y)) is corrected at steps S508 and S509. That is, it is a gradient p (x y) by calculating a formula 33 at step S508 using the count result of the formulas 37-43 in step S505, and a formula 30 and formulas 44-46. It is corrected. Here, the right-hand side of a formula 30 is each pixel location (x y). It is calculated as the average of the last value of the gradient in four pixel locations which adjoin four directions. moreover, the count result of the formulas 38, 39, 41, and 43 by which the right-hand side of formulas 44-46 was calculated at step S505 and a gradient p (x y) every of the three direction vectors ns1, ns2, and ns3 of the light source beforehand remembered to be the last values by memory 9 -- it is calculated based on the 1st element and the multiplier alpha (x y) calculated at step S501. furthermore, the formula 33 -- a constant lambda 1, lambda 2, and lambda 3 it is determined experientially that it mentioned above and it obtains in memory 9 beforehand -- having -- **** -- I1 (x y), I 2 (x y), and I3 (x y) processing of step S303 (refer to drawing 4) of drawing 3 -- the 1- of memory 9 -- it is obtained to the 3rd image field.

[0158] Moreover, it is a gradient q (x y) by calculating a formula 47 at step S509 using the count result of the formulas 37-43 in step S505, and a formula 48 and formulas 49-51. It is corrected. Here, the right-hand side of a formula 48 is each pixel location (x y). It is calculated as the average of the last value of the gradient in four pixel locations which adjoin four directions. moreover, the count result of the formulas 38, 39, 41, and 43 by which the right-hand side of formulas 49-51 was calculated at step S505 and a gradient q (x y) every of the three direction vectors ns1, ns2, and ns3 of the light source beforehand remembered to be the last values by memory 9 -- it is calculated based on the 2nd element and the multiplier alpha (x y) calculated at step S501. furthermore, the formula 47 -- a constant lambda 1, lambda 2, and lambda 3 it is determined experientially that it mentioned above and it obtains beforehand in memory 9 -- having -- **** -- I1 (x

y), I2 (x y), and I3 (x y) processing of step S303 (refer to <u>drawing 4</u>) of <u>drawing 3</u> — the 1- of memory 9 — it is obtained to the 3rd image field.

[0159] Then, steps S505 and S506 are performed again, and it is each pixel location (x y). Error E (x y) And the total about the total pixel location of the error is calculated, and while being judged with total of the error having not become below a predetermined threshold at step S507, processing of steps S508-S507 is repeated.

[0160] And if it judges that total of an above-mentioned error became below a predetermined threshold at step S507, it is each pixel location (x y). Since it can say that the gradient (p (x y) and q (x y)) was converged on the appropriate value, Each pixel location finally obtained at step S510 (x y) A gradient (p (x y) and q (x y)) is stored in memory 9, and, thereby, ends processing of step S302 of <u>drawing 3</u> .

Each pixel location obtained by above-mentioned processing before explaining the consideration by the bird's-eye view, next extract processing of the feature parameter of the shape of skin surface type of step S303 of <u>drawing 3</u> (x y) The example of the three-dimension configuration of the replica side 1 restored based on the gradient (p (x y) and q (x y)) which can be set is explained.

[0161] Each pixel location (x y) It is each pixel location (x y) by integrating with them in the fixed direction on a replica side image, if it can ask for a gradient (p (x y) and q (x y)). The value of the z-coordinate which can be set can be calculated and the three-dimension configuration of the replica side 1 can be restored.

[0162] <u>Drawing 6</u> is drawing having shown the three-dimension configuration of the replica side 1 restored by making it such as a bird's-eye view. As this drawing shows, in a leather slot field, when a gradient changes a lot shows being incised in the V character mold in the direction of -z.

[0163] Moreover, also in near the intersection of a leather slot and a leather slot, when a gradient changes a lot shows presenting a configuration characteristic of the direction of -z. on the other hand — leather — a hill — in a field, there is little change of a gradient and it presents the configuration near a flat surface.

Extract processing of the feature parameter of the shape of skin surface type of step S303 of <u>drawing 3</u> based on the consideration beyond the extract of a skin pulse duty factor is explained along with the operation flow chart of <u>drawing 7</u> .

[0164] First, a leather slot pulse duty factor is extracted at step S701. A leather slot pulse duty factor is defined by the rate of area to the whole replica side image of a leather slot field, and the field of the intersection (pore is included) of a leather slot and a leather slot is also included in a leather slot.

[0165] The operation flow chart of processing here is shown in <u>drawing 8</u> . <u>drawing 8</u> — setting — first — step S801 — each pixel location (x y) every — gradient reinforcement is calculated by the degree type using the gradient (p (x y) and q (x y)) calculated at step S302 of <u>drawing 3</u> . This physical quantity shows the strength of the inclination of the replica side 1 in each pixel location (x y).

[0166]

[Equation 53]

(グラディエント強度) ＝ ｛p (x,y)^2＋q (x,y)^2｝ $^{1/2}$

[0167] Next, pixel location which has the gradient reinforcement beyond a predetermined

threshold at step S802 (x y) It is extracted and the label in which it is shown that the pixel concerned is a leather slot is given to the pixel. Consequently, the pixel of a leather slot field is extracted in a replica side image. In addition, each pixel location used with a formula 53 (x y) Since it is the value determined that it mentioned above the gradient (p (x y) and q (x y)) by the algorithm of a relaxation method, a leather slot field is easily detectable with the easy above threshold processings.

[0168] While a leather slot pulse duty factor is calculated by the degree type and the count result is finally stored in memory 9 at step S803, it is outputted to a printer 11 or CRT display 12.

[0169]

[Equation 54]

（皮溝占有率）＝（皮溝領域の画素数）／（総画素数）

[0170] The leather slot pulse duty factor calculated as mentioned above serves as a feature parameter which shows the size of the field of the intersection (pore is included) of a leather slot and a leather slot. Generally, human being's skin is important for the ability to carry out the direct valuation of the leather slot pulse duty factor as mentioned above with aging, since the consistency of a leather slot decreases.

At step S702 of the standard deviation of the direction of a leather slot, and extract drawing 7 of a histogram, the standard deviation and the histogram of the direction of a leather slot are extracted. The direction of a leather slot is defined as a longitudinal direction of a leather slot.

[0171] The operation flow chart of processing here is shown in drawing 9 . pixel (x y) of the leather slot field which was able to be first found at step S802 of drawing 8 in step S901 in drawing 9 ******** –– the gradient direction is calculated by the degree type. This gradient direction is calculated in -pi/2 to pi/2 [rad].

[0172]

[Equation 55]

（グラディエント方向）＝ $\tan^{-1}${q (x, y)／p (x, y)}

[0173] The gradient direction in a leather slot field shows a direction perpendicular to the direction of a leather slot, i.e., the cross direction of a leather slot. Therefore, at step S902, pi/2 [rad] is added in the above-mentioned gradient direction by the degree type, consequently the direction of a leather slot is extracted.

[0174]

[Equation 56]

（皮溝方向）＝（グラディエント方向）＋π／2

[0175] And each pixel location which did in this way and was able to be found at step S903 (x y) While the standard deviation and the histogram of the whole leather slot field are calculated and the count result is stored in memory 9 about the direction of a leather slot which can be set, it is outputted to a printer 11 or CRT display 12.

[0176] When the standard deviation of the direction of a leather slot which can be found as mentioned above is small, it is shown that the leather slot is flowing in the fixed direction in the whole replica side image, and when standard deviation is large, it is shown

that the leather slot is running in all directions in the whole replica side image. Moreover, distribution of the direction of a leather slot can also be extracted by inspecting a histogram.

[0177] Generally, it is important for human being's skin that the direct valuation of the direction of a leather slot can be carried out as mentioned above in order to present the inclination for the homogeneity of the radial about a leather slot to be lost and for a leather slot to flow in the fixed direction with aging.

At step S703 of an average and standard deviation of the depth of a hide groove bottom, and extract drawing 7 of a histogram, the average, the standard deviation, and the histogram of the depth of a hide groove bottom are extracted. The depth of a hide groove bottom is most important parameter that determines the configuration of a leather slot.

[0178] Now, from drawing 2 , since the coordinate about the replica side 1 is defined like drawing 10 , Laplacian which is the sign of the gradient (p (x y) and q (x y)) which is the primary space differential of the depth in a leather slot field, and the secondary space differential of the depth becomes like a drawing. The information about the pixel and the depth of a hide groove bottom is extracted by the algorithm shown by the operation flow chart of drawing 11 using such a property.

[0179] drawing 11 — setting — first — step S1101 — each pixel location (x y) of a replica side image every — the secondary space differential of the depth of the replica side 1, i.e., Laplacian, is calculated. Since the depth value cannot be found directly here, it is a gradient p (x y). And q (x y) Laplacian is calculable by calculating the primary space differential px (x y) and qy (x y), and asking for those linear combination. In addition, what is necessary is to calculate a degree type to coincidence at the time of count of step S505, and just to make memory 9 memorize them by making the count result into Laplacian, since px (x y) and qy (x y) are calculated by the formula 52 at step S505 of drawing 5 about step S302 of drawing 3 .

[0180]

[Equation 57]

$$(\text{ラプラシアン}) = p_x (x, y) + q_y (x, y)$$

[0181] Next, one pixel which step S1102 is searched for the pixel from which Laplacian serves as the forward maximal value beyond a predetermined threshold by the whole replica side image, and fills it with it is extracted as a pixel candidate of a hide groove bottom.

[0182] If the pixel candidate of a hide groove bottom is found, the judgment of step S1103 will serve as YES, next it will be searched for whether the leather slot field which has been found at step S802 of drawing 8 about step S701 of drawing 7 exists in the latest pixel around the pixel candidate of a hide groove bottom in step S1104.

[0183] When a leather slot field is not found, since the pixel candidate of the hide groove bottom concerned can judge with it not being the pixel of a hide groove bottom, the judgment result of step S1105 serves as NO, and he returns to step S1102. On the other hand, when a leather slot field is found, since the pixel candidate of the hide groove bottom concerned can judge with it being the pixel of a hide groove bottom, the judgment result of step S1105 serves as YES, and he progresses to step S1106.

[0184] At step S1106, label attachment of the above-mentioned leather slot pixel

candidate is carried out as a leather slot pixel. Then, processing about an integral is performed in steps S1107 and S1108. Now, as shown in <u>drawing 10</u> , it can be defined as the depth in the pixel of a hide groove bottom being the height from the pixel of a hide groove bottom to the pixel of the edge of the leather slot where it is contained. Then, it can ask for the depth of the pixel of a hide groove bottom by integrating with a gradient from the pixel of a hide groove bottom to the pixel of the edge of a leather slot.

[0185] First, it is determined at step S1107 whether to make the integral direction into x directions or consider as the direction of y. Namely, the average of the gradient (p (x y) and q (x y)) of the pixel of the predetermined range in the leather slot field detected in step S1104 is calculated, and if the average of p (x y) is larger Since it can presume that the direction of a leather slot of the leather slot field where the pixel of the hide groove bottom is contained has turned to the direction near the direction of y as shown in <u>drawing 12</u> , x directions are determined as a retrieval direction so that retrieval may be performed to the direction near the cross direction of a leather slot. On the contrary, q (x y) If the average is larger, since it can presume that the direction of a leather slot of the leather slot field where the pixel of the hide groove bottom is contained has turned to the direction near x directions as shown in <u>drawing 13</u> , the direction of y will be determined as a retrieval direction so that retrieval may be performed to the direction near the cross direction of a leather slot. Thereby, an integral will be performed in the direction of a leather slot, and the situation of it becoming impossible for the path of integration to slip out from a leather slot can be prevented.

[0186] Moreover, at step S1107, distinction which makes the integral direction which the forward or negative direction where the effective lightness value is acquired is also performed in x directions or the direction of y determined as mentioned above. This is the relation between the lighting direction of the light source, and the direction of a leather slot, and since the part which becomes the shadow of lighting may arise and the gradient may not be correctly found in the part of the shadow, it is for avoiding the direction where the part of such a shadow is contained. Whether the effective lightness value is acquired For example, 1st light source 2A, the 2nd light source 2B, And by investigating distribution of the lightness value of the whole image and performing threshold processing about each of the image data of three sheets stored in memory 9 corresponding to each lighting actuation of the replica side 1 by 3rd light source 2C It can distinguish by processing carrying out label attachment of whether the effective lightness value is acquired for every pixel beforehand etc.

[0187] At step S1108, integral processing is performed in the range of the leather slot field which has been found in the integral direction determined at step S1107 at step S802 of <u>drawing 8</u> about step S701 of <u>drawing 7</u> . In this case, when an integral is performed in the x directions, it is a gradient p (x y). When it finds the integral and an integral is performed in the direction of y, it is a gradient q (x y). It finds the integral.

[0188] The integral value acquired as a result of the integral is step S1109, and is memorized by memory 9 as the depth in the pixel of the hide groove bottom concerned. Then, again, on return and a replica side image, it is further searched for the pixel from which Laplacian serves as the forward maximal value beyond a predetermined threshold by step S1102, one pixel which fills it is extracted as a pixel candidate of a hide groove bottom, and processing of steps S1104-S1109 is repeated to it.

[0189] If the pixel from which Laplacian serves as the forward maximal value beyond a predetermined threshold stops finding, the judgment of step S1103 will serve as NO, and will progress to step S1110. At step S1110, the average, the standard deviation, and the histogram of the depth in the whole replica side image of a pixel of a hide groove bottom by which label attachment was carried out are calculated, and while the count result is stored in memory 9, it is outputted to a printer 11 or CRT display 12.

[0190] Generally, since the hide depth of flute becomes shallow and becomes indistinct [a leather slot] with aging, human being's skin is important for the ability to carry out the direct valuation of the hide depth of flute as mentioned above.
At step S704 of an average and standard deviation of a hide flute width, and extract drawing 7 of a histogram, an average, the standard deviation, and the histogram of a hide flute width are extracted.

[0191] The operation flow chart of processing here is shown in drawing 14 . First, the number of integral pixels in the integral processing performed at step S1108 of drawing 11 mentioned above at step S1401 for every pixel of the hide groove bottom extracted at step S1106 of drawing 11 about step S703 of drawing 7 mentioned above is extracted. In addition, what is necessary is to count the number of integral pixels, when integral processing of step S1108 is performed, to make it correspond to the pixel of a hide groove bottom in step S1109 at the time of integral termination, and just to make memory 9 memorize it.

[0192] Next, based on the above-mentioned number of integral pixels, a hide flute width is calculated for every pixel of a hide groove bottom at step S1402. When an integral is performed in the x directions at step S1108 of drawing 11 mentioned above, the relation between the number of integral pixels in the pixel of a hide groove bottom and the hide flute width of a there is shown in drawing 15 . Then, the hide flute width in the pixel of a hide groove bottom is calculated by the degree type.

[0193]
[Equation 58]

（皮溝底の画素での皮溝幅）

＝２×（皮溝底の画素での積分画素数）

×（積分路上の平均のグラディエント方向の余i

[0194] Moreover, when an integral is performed in the direction of y at step S1108 of drawing 11 , the relation between the number of integral pixels in the pixel of a hide groove bottom and the hide flute width of a there is shown in drawing 16 . Then, the hide flute width in the pixel of a hide groove bottom is calculated by the degree type, and while the count result is stored in memory 9, it is outputted to a printer 11 or CRT display 12.

[0195]
[Equation 59]

（皮溝底の画素での皮溝幅）

＝2×（皮溝底の画素での積分画素数）

×（積分路上の平均のグラディエント方向の正弦値）

[0196] The gradient direction of the average on the path of integration used with a formula 58 or a formula 59 here For example, when integral processing of step S1108 is performed, the gradient direction calculated about the pixel with which it integrates at step S901 of drawing 9 about step S702 of drawing 7 is added. What is necessary is to be able to ask by doing the division of the aggregate value with the number of integral pixels in step S1109 at the time of integral termination, to make the average of the gradient direction which made it such and was able to be found correspond to the pixel of a hide groove bottom, and just to make memory 9 memorize it in step S1109.

[0197] The hide flute width is important for the ability to carry out the direct valuation of the hide flute width as mentioned above with the depth of a hide groove bottom, since it becomes an index for getting to know the aging condition of human being's skin.
At step S705 of extract drawing 7 of a leather slot segment, the segment which connects the pixel of a hide groove bottom, i.e., a leather slot segment, is extracted.

[0198] The operation flow chart of processing here is shown in drawing 17 . First, the label of a leather slot segment is given at step S1701 for every pixel of the hide groove bottom extracted at step S1106 of drawing 11 about step S703 of drawing 7 mentioned above.

[0199] In this case, label attachment is performed by doubling with the pixel of the hide groove bottom which pays its attention to the pixel shown by the black dot of various operators' center as shown in drawing 18 or drawing 19 now, and distinguishing whether the pixel of a hide groove bottom exists only in the pixel shown with a circle [of the circumference of it / white].

[0200] When which operator shown in drawing 18 suits here, the black dot pixel of the hide groove bottom to which its attention is paid now is a pixel in the middle of a leather slot segment. And when the label is given to neither of the pixels of a white round head, a new common label is given to the pixel of other hide groove bottoms shown with a circle [of a hide groove bottom / the black dot pixel and with a circle / white] currently are carrying out current view, and memory 9 memorizes the information. Moreover, when the label is given to which pixel of a white round head, it is given to the pixel of the hide groove bottom shown with a circle [of a hide groove bottom / the black dot pixel and with a circle / white / other] currently are carrying out the current view of the label, and the information is memorized by memory 9.

[0201] On the other hand, when which operator shown in drawing 19 suits, the black dot pixel of the hide groove bottom to which its attention is paid now is a pixel of the endpoint of a leather slot segment. And when the label is not given to the pixel of a white round head, a new common label is given to the pixel of other hide groove bottoms shown with a circle [of the hide groove bottom which is carrying out current view / the black dot pixel and with a circle / white], and the information is memorized by memory 9. Moreover, when the label is given to the pixel of a white round head, it is given to the black dot pixel of the hide groove bottom which is carrying out the current view of the

label, and the information is memorized by memory 9. Furthermore, the label given to the black dot pixel of the hide groove bottom to which its attention is paid now is made to correspond, and the information which shows that the location and location of the black dot pixel concerned are the endpoint of a leather slot segment where the label concerned is given is memorized by memory 9.

[0202] Next, at step S1702, the slant range between an endpoint and two locations is calculated for every class of each label by the information on the endpoint location of the both ends of the leather slot segment corresponding to the label concerned being read from memory 9, and the count result is extracted as die length (leather slot segment length) of the leather slot segment corresponding to the label concerned, makes the label concerned correspond, and is memorized by memory 9.

[0203] Then, while the number of the classes of label is read, the number is extracted from memory 9 as a number of the leather slot segment in a replica side image and the result is stored in memory 9 at step S1703, it is outputted to a printer 11 or CRT display 12.

[0204] Furthermore, while the leather slot segment length extracted at step S1702 is read from memory 9, those averages and standard deviation, and a histogram are extracted and the result is stored in memory 9 at step S1704, it is outputted to a printer 11 or CRT display 12.

[0205] Generally, it is important for human being's skin that the number of leather slots decreases, and it can carry out the direct valuation of the number of a leather slot segment and the leather slot segment length as mentioned above with aging since the die length of a leather slot becomes long.

At step S706 of drawing 7 , the abundance of the pore in the intersection of a leather slot segment, the depth, and magnitude are extracted by the abundance of pore, the depth, and the extract last of magnitude.

[0206] The operation flow chart of processing here is shown in drawing 20 . At introduction and step S2001, the field (intersection field) of the intersection of a leather slot segment is extracted.

[0207] Therefore, the pixel which was not set as the object of the integral processing performed at step S1108 of drawing 11 about the hide groove bottom pixel first extracted at step S1106 of drawing 11 about step S703 of drawing 7 among the pixels of the leather slot field extracted at step S701 of drawing 7 is extracted as a candidate of an intersection field. The intersection field of a leather slot has strong possibility of not being set as the object of integral processing of a hide groove bottom so that it may be now shown as the slash section of drawing 21 . Therefore, it can be presumed that an intersection field is included in the candidate of the intersection field extracted as mentioned above.

[0208] Next, it is divided for every field where the candidate of an intersection field continues, a label is given to each, and the information is memorized by memory 9. Then, when it is judged whether the candidate of an above-mentioned intersection field exists in predetermined within the limits and it exists from the endpoint location for every endpoint location of each **** segment which is extracted at step S705 of drawing 7 , and is memorized by memory 9, the label of the leather slot segment concerned is matched with the label of the candidate of the intersection field concerned, and the

information is memorized by memory 9.

[0209] The candidate of the intersection field where the label of two or more leather slot segments is given is extracted as an intersection field after above-mentioned processing, and the information (label) is memorized by memory 9.

[0210] At step S2002, the depth of each intersection field extracted at step S2001 is extracted. First, one leather slot segment connected to it is determined for every intersection field.

[0211] And about the hide groove bottom pixel of the endpoint location by the side of the intersection field concerned of the determined leather slot segment, the depth information on the hide groove bottom pixel concerned extracted at step S703 of drawing 7 is read from memory 9, and the gradient of each pixel location finds the integral toward an intersection field side by making the depth into initial value from the hide groove bottom pixel concerned.

[0212] In this case, in each pixel location, it is p (x y). And q (x y) Inside, It has a negative sign, and a gradient with a larger absolute value is chosen, and it finds the integral, and is p (x y). When it finds the integral, 1 pixel moves in the +x direction, and it is q (x y). When it finds the integral, 1 pixel moves in the direction of +y, and integral processing is repeated further.

[0213] And when the depth becomes the deepest, integral processing is ended, and the depth information is memorized by memory 9 as a candidate of intersection depth information. Above-mentioned integral processing is similarly performed about all the leather slot segments connected to the intersection field which is carrying out current view. And a value with the deepest depth is extracted as the depth of the intersection field which is carrying out current view among the candidates of the intersection depth information acquired about all leather slot segments.

[0214] Then, at step S2003, it is judged for the intersection field concerned by judging whether the depth of the intersection field concerned extracted at step S2002 is deeper than a predetermined threshold about each of the intersection field extracted at step S2001 whether it is pore. Generally pore is incised deeply and, on the other hand, the depth of the mere intersection which is not pore seldom changes to the depth of a hide groove bottom. Therefore, pore can be extracted by judging the depth of an intersection field. About the intersection field judged to be pore, the label of the purport which is pore is attached and the information is memorized by memory 9.

[0215] Furthermore, at step S2004, the magnitude is extracted about the pore extracted at step S2003. In an intersection field, since the leather slot segment which touches it can be modeled if it touches with the hide flute width of each ****, it can extract the magnitude of pore by extracting the number of pixels of the intersection field surrounded by the hide flute width of each **** segment which touches it about the intersection field of pore with a suitable algorithm. Thus, the information on the magnitude of the detected pore At the last memorized by memory 9, at step S2006 A number of pore of rates extracted at step S2003 to the number of the intersection fields extracted at step S2001 are extracted as abundance of pore. Furthermore, the average, the standard deviation, and the histogram of magnitude of an average and standard deviation of the depth of pore and a histogram, and pore are extracted, and the result is outputted to a printer 11 or CRT display 12, while being stored in memory 9.

[0216] Generally, in order to present the inclination for pore to serve as an index for getting to know the aging condition of human being's skin, for example, for the magnitude of pore to become large with aging, it is important that the direct valuation of the pore can be carried out as mentioned above.

[0217] According to the skin surface type-like feature-extraction equipment explained above, abundance, the depth, magnitude, etc. of pore can be evaluated now in a detail at the number of a leather slot pulse duty factor, the direction of a leather slot, the hide depth of flute, a hide flute width, and a leather slot segment and leather slot segment length, and a list by the ability extracting the three-dimension configuration of the replica side 1 through a gradient.

You may constitute so that the bird's-eye view of the three-dimension configuration of the replica side 1 as shown in CRT display 12 of drawing 1 at drawing 6 which is example > besides < may be calculated and displayed.

[0218] Moreover, in the operation flow chart of drawing 5 about the computation of the gradient of step S302 of drawing 3 , the count precision of a gradient can be raised by being made not to make presumption of a gradient (p (x y) and q (x y)), and the correction by the relaxation method about the part which becomes the shadow of lighting by the relation between the lighting direction of the light source, and the direction of a leather slot. In this case, since it is processed so that only the direction where the effective lightness value as an integral direction is acquired in step S1107 may be chosen in case integral processing of step S1108 of drawing 11 about step S703 of drawing 7 is performed, in count of the depth of a hide groove bottom pixel etc., it does not produce un-arranging.

[0219] Furthermore, although the replica side 1 was illuminated by 1st light source 2A, the 2nd light source 2B, and the three light sources of 3rd light source 2C in the above-mentioned example If it illuminates according to much more light sources, three lightness values corresponding to the lighting which does not produce a shadow are chosen for every pixel location and a gradient is corrected with presumption and a relaxation method, it is also possible to ask for the gradient of all pixel locations correctly.

[0220] In addition, it is also possible to constitute so that multiple-times lighting may be carried out, rotating the one light source around the replica side 1. In addition, error E of a formula 23 (x y) lambda 1 of the formula 25 for calculating, lambda 2, and lambda 3 may be dynamically changed according to the input state of a replica side image, for example, although each is the constant which appoints the contribution to the error E of the square error term of each light source direction by which multiplication is carried out (x y) and was experientially defined in the above-mentioned example, as mentioned above.

[0221] Although the skin surface type-like description was extracted from the replica side image in the above-mentioned example, you may make it conditions extract the skin surface type-like description from the image which picturized the skin front face directly on the other hand.

[0222] Furthermore, the algorithm for extracting the skin surface type-like feature parameter explained in the above-mentioned example is an example, and can apply algorithms various otherwise. For example, in count of a skin pulse duty factor, the algorithm which judges combining the image data of a lightness value from the first, uses the fact that Laplacian changes at the edge of a leather slot field (it changes to negative

in <u>drawing 10</u>), or is further extracted by the technique of field division of a leather slot segment of the whole leather slot field can be considered.

[0223]

[Effect of the Invention] According to this invention, since a skin surface type-like three dimension configuration can be extract through the inclination in each pixel location, it become possible to evaluate in a detail the description information about the rate that the field of the configuration of the field of the configuration of a leather slot, area, a direction, the depth, width of face, die length, the description information about a number, or the intersection field of a leather slot and the pore of a there exist, the depth of pore, or magnitude etc.

[0224] Thus, since the description information which shows the configuration directly can estimate the description of the shape of skin surface type which was not able to be evaluated indirectly conventionally, this invention becomes possible [mitigating an evaluation error sharply].

[0225] Moreover, since the configuration of this invention is easily realizable with small image pick-up equipment, the microcomputer of a pocket mold, etc., anyone is enabled to obtain easily and detailed objective rating can be easily used at shop fronts, such as a hospital or a chemist's shop, and a cosmetics store, etc.

[Translation done.]